

# National Cancer Outcomes Database

## A Collaborative Approach to Enhancing Patient Outcomes Analysis

---

June 21, 2010

***SAS Institute***

Ken Wright

Director R&D Solutions OnDemand

Eric Brinsfield

Director R&D Health and Life Sciences



THE  
POWER  
TO KNOW.

# About SAS

## *Our Company*



- The leader in business analytics software and services, delivering THE POWER TO KNOW®
- \$2.31 billion worldwide revenue in 2009; an unbroken track record of revenue growth every year since 1976
- Continuous reinvestment in research and development, including 23% of revenue in 2009
- Ranked No. 1 on FORTUNE magazine's 2010 "100 Best Companies to Work For" in America list
- More than 11,000 employees, 400 offices and 600 alliances globally

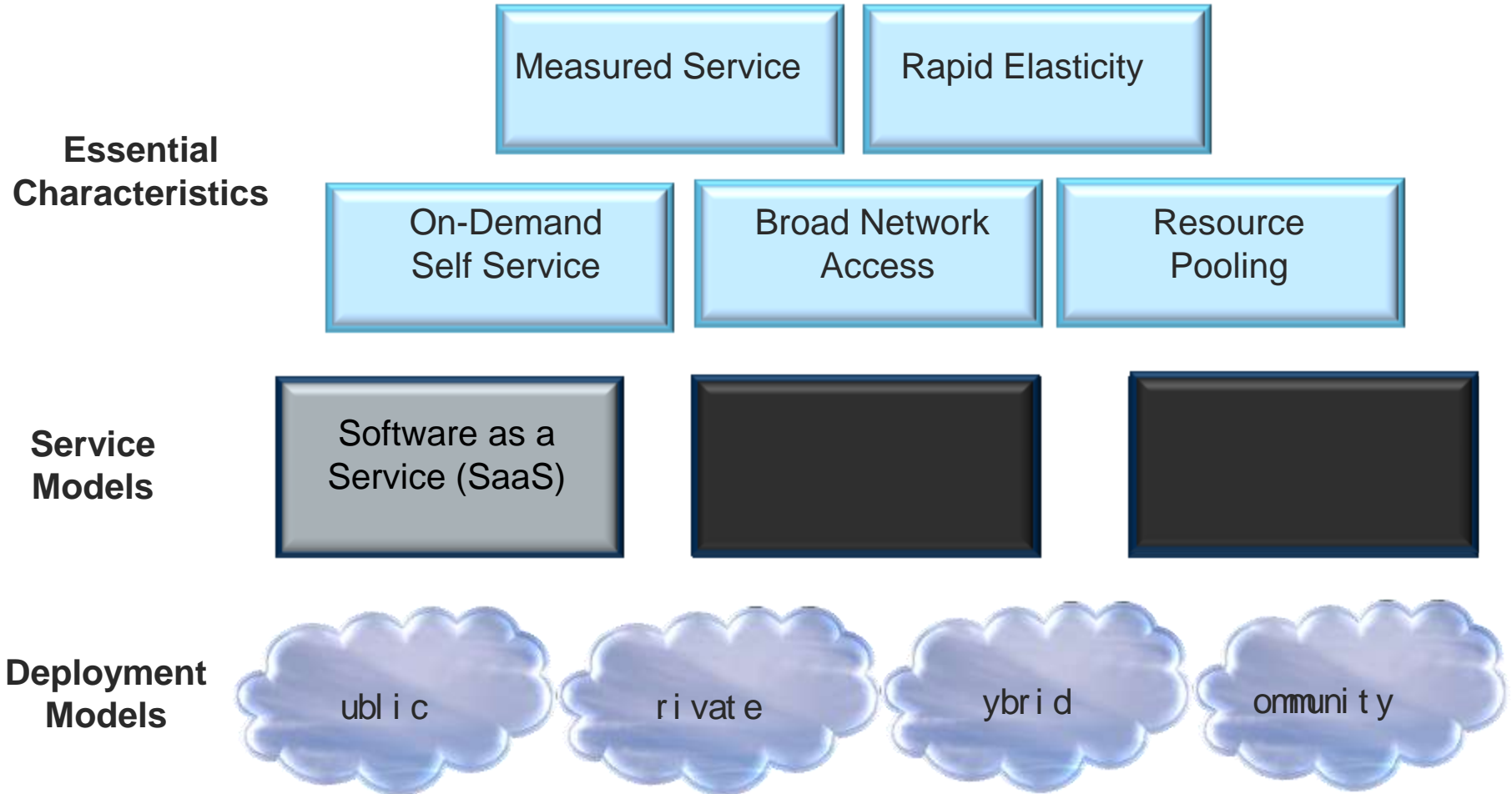
# SAS Solutions OnDemand

## *Software-as-a-Service and Enterprise Hosting*

- **Infrastructure:** A secure, high-performance data processing infrastructure, with 99 percent or greater availability guaranteed in service level agreements.
- **Expertise:** “The right expert at the right time” for optimizing the infrastructure, the data warehousing foundation and the business intelligence applications — the total solution.
- **Communication:** Single point of contact for customer liaison and project management, with “the buck stops here” accountability for the end-to-end solution.
- **Flexibility:** No up-front technology investments; allows customers to manage risk and scale for growth as their business dictates.

# Definition of Cloud Computing (NIST)

Fundamentally: **on demand** access to shared pool of computing resources

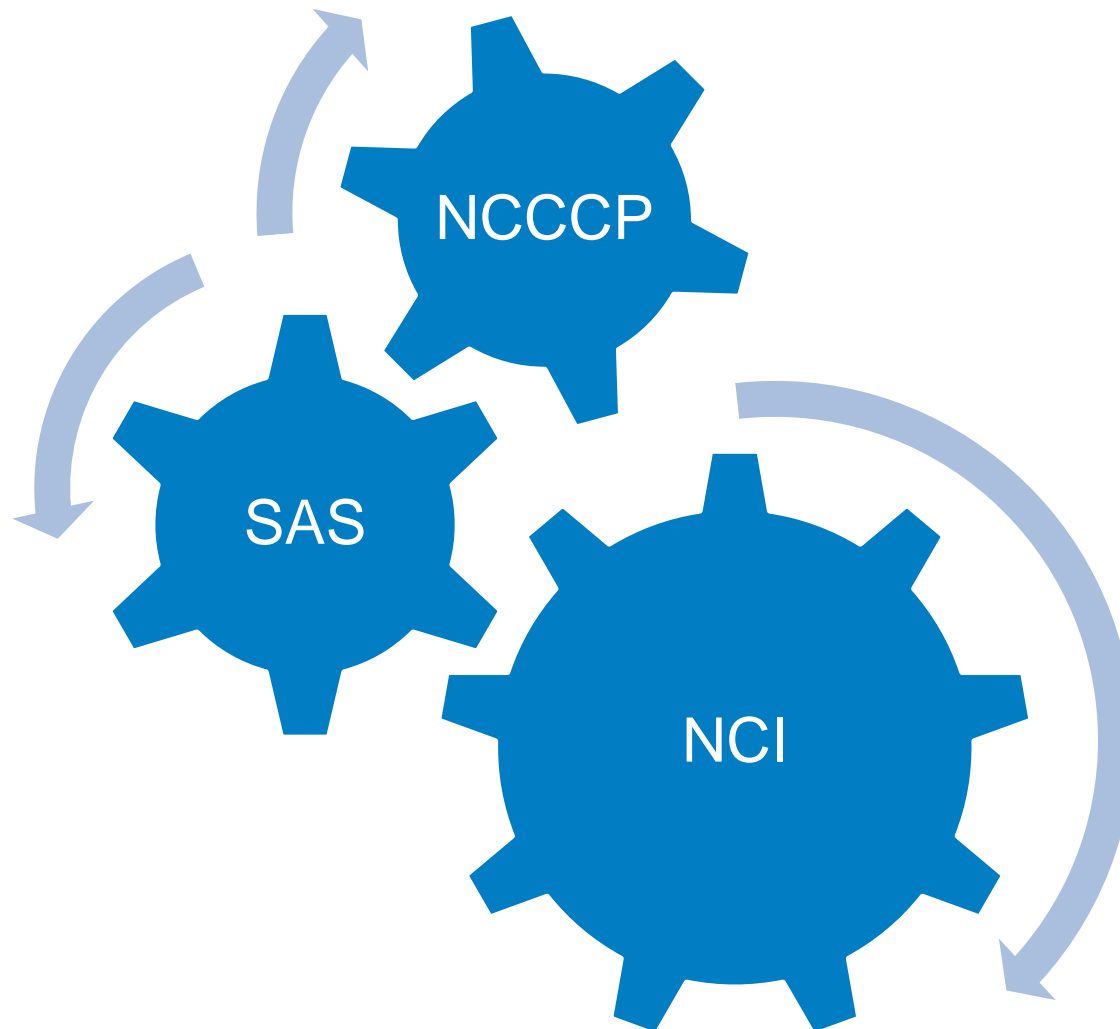


# High Performance Computing

- Growing needs for:
  - Advanced analytics
  - Fast loading from many different data sources
  - High availability
- Massive parallel processing (MPP) and distributed computing
  - Allows for dividing tasks into smaller tasks and distributing them to many nodes in the cluster for parallel processing
  - Provides a distributed architectures for analysis

# National Cancer Outcomes Database

*Collaboration between NCI, NCCCP, and SAS*



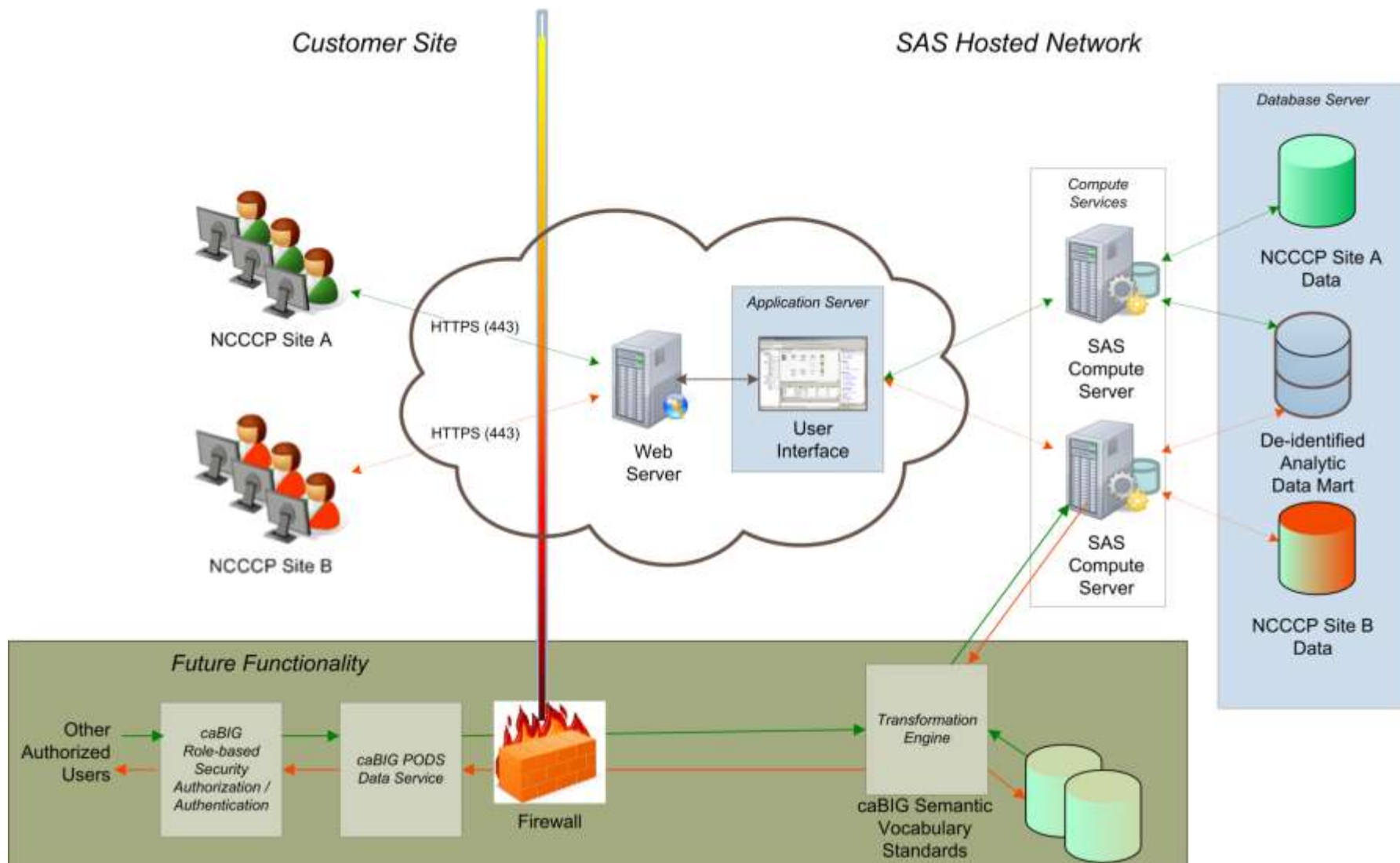
# National Cancer Outcomes Database

## *Initial Project Objectives*

- Design and implement Outcomes Data Model
- Load and standardize data from 4 NCCCP sites
- Provide comprehensive view of individual patients
- Summary Statistics on Historical Outcomes
  - » For treatment planning
  - » For evidence-based medicine
- Advanced analytical methods
  - » Association and sequence analysis
  - » Covariate analysis (adjusting for confounding)
  - » Predictive analytics
- Research high-performance computing options

# National Cancer Outcomes Database

## Logical Architecture



# Select a Patient from the Search Results...

SAS® sasbkd [SAS Developers]

HelpLog Off

SearchAlertsWatchlist

Patient Identifiers

MRN:

First name:

Middle name:

Last name:

SSN:

Street address:

City:

ZIP:

Country:

Sex:

Search

Clear

Search Results

MARCUS DANIEL WADEMRN: 1111111SSN: 1111111111  
Address: 520 NEWTON STREET  
Birth date: 01/01/1969Age: 40Race: WHITESex: MALE

MARK ANDREW WADEMRN: 222222SSN: 2222222222  
Address: 22 Florence Street  
Birth date: 01/01/1950Age: 59Race: BLACKSex: MALE

MARC C WHITEMRN: 3333333SSN: 3333333333  
Address: 22 Washington Street  
Birth date: 04/24/1968Age: 40Race: WHITESex: MALE

MARK ISSAC WADEMRN: 44444444SSN: 4444444444  
Address: 103 Freeway Drive  
Birth date: 04/25/1950Age: 59Race: WHITESex: MALE

# Patient Summary

SAS® sasbkd [SAS Developers]

HelpLog Off

SearchAlertsWatchlistM. WADE

Patient: MARCUS DANIEL WADE MRN: 111111 SSN: 111111111 DOB: 1969-01-01 Age: 40 Sex: MALE Race: WHITE Ethnicity: Non-Hispanic Add to WatchlistAnalyze

Flags: Diabetes Risk of Lymphedema Penicillin Codeine

SummaryHistoryProvidersEncountersObservationsLabsDiagnosesInterventionsOutcomesPatient Profile

Personal Information			Contact Information	
Name:	Marcus Daniel Wade		Home Phone:	(943) 865-4321
Address 1:	520 Newton St.		Work Phone:	(943) 913-9342
Address 2:	Apt 211-C		Cell Phone:	(943) 913-1945
City/State/Zip Code:	Burlington, NC 28432		Emergency Contact:	Delores Wade (943) 553-9342
SSN:	111111111		E-mail:	MVWade@fakemail.com
Occupation:	Electrician			

Most Recent Vitals			Performance Status	
Date: 04/01/2009	Height: 67 in	Weight: 195 lbs	Baseline	
BP: 140/95	Pulse: 82 BPM	Temp: 99F	Date: 05/01/2009	ECOG: 0
			Recent	
			Date: 12/30/2009	ECOG: 2

# Background of Patient in Patient Detail View

This patient was diagnosed with prostate cancer in May of 2009.

5/1/2009	T category: Tumor confined to prostate; Less than 50% one lobe	T2a
5/1/2009	N category: No regional lymph node involvement	N0
5/1/2009	M category: No distant metastasis	M0
5/1/2009	Gleason score	2
5/1/2009	Histological grade finding ( Well differentiated (slight anaplasia)	G1
5/1/2009	Stage	II

The patient was treated with 6 weeks of external beam radiation therapy for 10 minutes daily for 5 days a week.

ECOG performance scores were collected before treatment and at the end of each week of treatment.

6 months after completion of treatment, indications suggest that the prostate cancer is returning.

# Patient Encounters

SAS® sasbkd [SAS Developers]

Help
Log Off

Search
Alerts
Watchlist
M. WADE

Patient: MARCUS DANIEL WADE MRN: 111111 SSN: 111111111 DOB: 1969-01-01 Age: 40 Sex: MALE Race: WHITE Ethnicity: Non-Hispanic
Add to Watchlist
Analyze

Flags: Diabetes Risk of Lymphedema Penicillin Codeine

Summary
History
Providers
Encounters
Observations
Labs
Diagnoses
Interventions
Outcomes
Patient Profile

Date	Encounter Type	Purpose	Provider	Specialty	Referring Physician	Specialty
12/30/2009	Office	Physical Exam	John Trump, M.D.	Internal Medicine	John Trump, M.D.	Internal Medicine
12/23/2009	Clinic	Blood/Urine Sample		Lab Technician	John Trump, M.D.	Internal Medicine
5/1/2009	Analysis	Pathology Interpretation	Beth Collins, M.D.	Pathology	Kurt McKenzie, M.D.	Medical Oncology
4/25/2009	Out-Patient	Biopsy	Kurt McKenzie, M.D.	Medical Oncology	Kurt McKenzie, M.D.	Medical Oncology
4/20/2009	Out-Patient	Consult	Kurt McKenzie, M.D.	Medical Oncology	John Trump, M.D.	Internal Medicine
4/10/2009	Out-Patient	Transrectal Ultrasound	Mia D'Amico, M.D.	Radiology	John Trump, M.D.	Internal Medicine
4/1/2009	Office	Physical Exam	John Trump, M.D.	Internal Medicine	John Trump, M.D.	Internal Medicine
3/15/2009	Clinic	Blood/Urine Sample		Lab Technician	John Trump, M.D.	Internal Medicine
12/20/2006	Office	Follow-Up	Janet Oster, M.D.	Orthopedic Surgeon	Janet Oster, M.D.	Orthopedic Surgeon
12/8/2006	Office	Follow-Up	Janet Oster, M.D.	Orthopedic Surgeon	Janet Oster, M.D.	Orthopedic Surgeon
11/28/2006	In-Patient	Physical Therapy	Ben Shore	Physical Therapy	Janet Oster, M.D.	Orthopedic Surgeon
11/27/2006	In-Patient	Recovery	Mary Barden	RN	Janet Oster, M.D.	Orthopedic Surgeon
11/27/2006	In-Patient	Knee Surgery	Janet Oster, M.D.	Orthopedic Surgeon	Janet Oster, M.D.	Orthopedic Surgeon
11/26/2006	ER	Consult	Janet Oster, M.D.	Orthopedic Surgeon	Rajiv Patel, M.D.	Emergency Medicine
11/26/2006	ER	Knee Injury	Rajiv Patel, M.D.	Emergency Medicine	Rajiv Patel, M.D.	Emergency Medicine
6/2/2000	Office	Physical Exam	John Trump, M.D.	Internal Medicine	John Trump, M.D.	Internal Medicine
5/26/2000	Clinic	Blood/Urine Sample		Lab Technician	John Trump, M.D.	Internal Medicine
2/4/1995	Office	Physical Exam	John Trump, M.D.	Internal Medicine	John Trump, M.D.	Internal Medicine
2/1/1995	Clinic	Blood/Urine Sample		Lab Technician	John Trump, M.D.	Internal Medicine

# Patient Observations

SAS® sasbkd [SAS Developers]			
Help			
Log Off			
<div> <a href="#">Search</a> <a href="#">Alerts</a> <a href="#">Watchlist</a> <a href="#">M. WADE</a> </div>			
Patient: MARCUS DANIEL WADE MRN: 111111 SSN: 111111111 DOB: 1969-01-01 Age: 40 Sex: MALE ♂ Race: WHITE Ethnicity: Non-Hispanic <a href="#">Add to Watchlist</a> <a href="#">Analyze</a>			
Flags: Diabetes Risk of Lymphedema Penicillin Codeine			
<a href="#">Summary</a> <a href="#">History</a> <a href="#">Providers</a> <a href="#">Encounters</a> <a href="#">Observations</a> <a href="#">Labs</a> <a href="#">Diagnoses</a> <a href="#">Interventions</a> <a href="#">Outcomes</a> <a href="#">Patient Profile</a>			
Date	Code	Value	Description
5/1/2009	Stage	II	
5/1/2009	SNOMEDCT 78873005	T2a	T category
5/1/2009	SNOMEDCT 27720609	N0	N category
5/1/2009	SNOMEDCT 27720805	M0	M category
5/1/2009	SNOMEDCT 372278000	2	Gleason score
5/1/2009	SNOMEDCT 373372005	G1	Histological grade finding
4/10/2009	NCI C18315	Gland Volume=45cm3	Transrectal Ultrasound
4/1/2009	SNOMEDCT 386725007	99F	Body Temperature
4/1/2009	SNOMEDCT 78564009	82 bpm	Pulse Rate
4/1/2009	SNOMEDCT 407554009	140	Sitting systolic blood pressure
4/1/2009	SNOMEDCT 407555005	95	Sitting diastolic blood pressure
4/1/2009	SNOMEDCT 50373000	67 inches	Body height
4/1/2009	SNOMEDCT 27113001	195 lbs	Body weight
6/2/2000	SNOMEDCT 386725007	98.9F	Body Temperature
6/2/2000	SNOMEDCT 78564009	80 bpm	Pulse Rate
6/2/2000	SNOMEDCT 407554009	160	Sitting systolic blood pressure
6/2/2000	SNOMEDCT 407555005	100	Sitting diastolic blood pressure
6/2/2000	SNOMEDCT 50373000	67 inches	Body height
6/2/2000	SNOMEDCT 27113001	200 lbs	Body weight
2/4/1995	SNOMEDCT 386725007	98.6F	Body Temperature
2/4/1995	SNOMEDCT 78564009	69 bpm	Pulse Rate
2/4/1995	SNOMEDCT 407554009	138	Sitting systolic blood pressure

# Patient Labs (Tabular)

SAS® sasbkd [SAS Developers]

Help

Log Off

Search

Alerts

Watchlist

M. WADE

Patient:

MARCUS DANIEL WADE

MRN:

111111

SSN:

111111111

DOB:

1969-01-01

Age:

40

Sex:

MALE

Race:

WHITE

Ethnicity:

Non-Hispanic

Add to Watchlist

Analyze

Flags:

Diabetes

Risk of Lymphedema

Penicillin

Codeine

Summary

History

Providers

Encounters

Observations

Labs

Diagnoses

Interventions

Outcomes

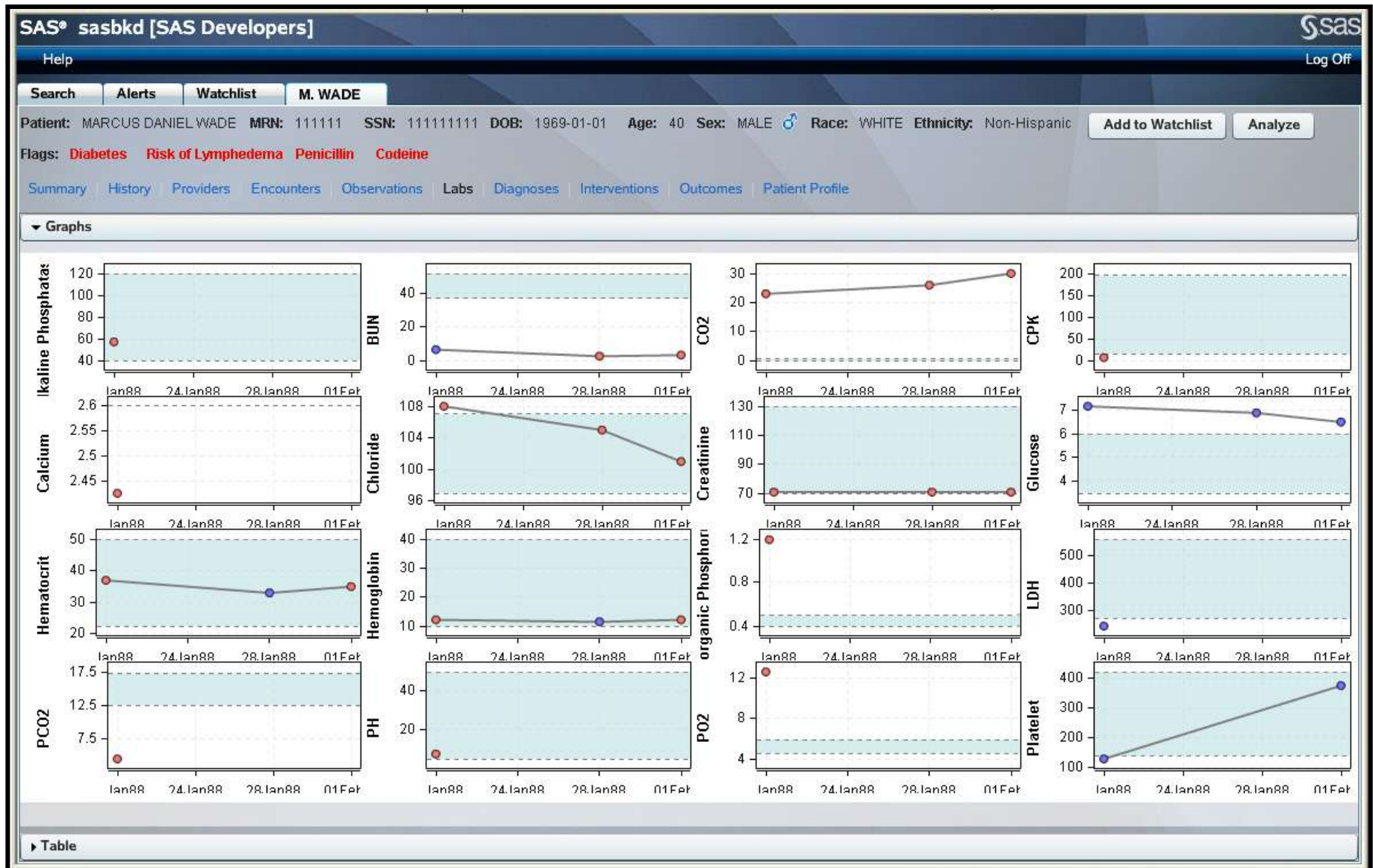
Patient Profile

Graphs

Table

Date Collected	Date Reported	Sample Type	Lab Order	Lab Test	Value	Units	Normal Range	Out of Range
3/5/2010 14:21	3/7/2010 09:30	Blood	CBC and DIFF (In House) MALE	WBC	7.1	10 X 3/uL	4.0-10.5	
				Lymphocyte %	19.9	%	20.5-51.1	Abnormal
				MCH	32.0	pg	27.0-34.0	
			Lipid Panel w LDL/HDL	Cholesterol, Total	170	mg/dL	100-199	
				Triglycerides	43	mg/dL	0-149	
				HDL Cholesterol	60	mg/dL	40-59	Abnormal
3/5/2010 14:21	3/7/2010 09:30	Urine	Prostate-Specific Ag, Serum	Prostate-Specific Ag, Serum	1.0	ng/mL	0.0-4.0	
			Creatinine	Creatinine	0.7	mg/dL	0.5-1.0	
3/5/2010 14:21	3/7/2010 09:30	Blood	CBC and DIFF (In House) MALE	Creatinine clearance	115	mL/min	110-120	
				WBC	7.1	10 X 3/uL	4.0-10.5	
				Lymphocyte %	19.9	%	20.5-51.1	Abnormal
			Lipid Panel w LDL/HDL	MCH	32.0	pg	27.0-34.0	
				Cholesterol, Total	170	mg/dL	100-199	
				Triglycerides	43	mg/dL	0-149	
3/5/2010 14:21	3/7/2010 09:30	Urine	HDL Cholesterol	60	mg/dL	40-59	Abnormal	
			Prostate-Specific Ag, Serum	Prostate-Specific Ag, Serum	1.0	ng/mL	0.0-4.0	
			Creatinine	Creatinine	0.7	mg/dL	0.5-1.0	
3/5/2010 14:21	3/7/2010 09:30	Urine	Creatinine clearance	115	mL/min	110-120		

# Patient Labs (Graphical)



16

# Patient Interventions

SAS® sasbkd [SAS Developers]

HelpLog Off

SearchAlertsWatchlistM. WADE

Patient: MARCUS DANIEL WADE MRN: 111111 SSN: 111111111 DOB: 1969-01-01 Age: 40 Sex: MALE Race: WHITE Ethnicity: Non-Hispanic Add to WatchlistAnalyze

Flags: Diabetes Risk of Lymphedema Penicillin Codeine

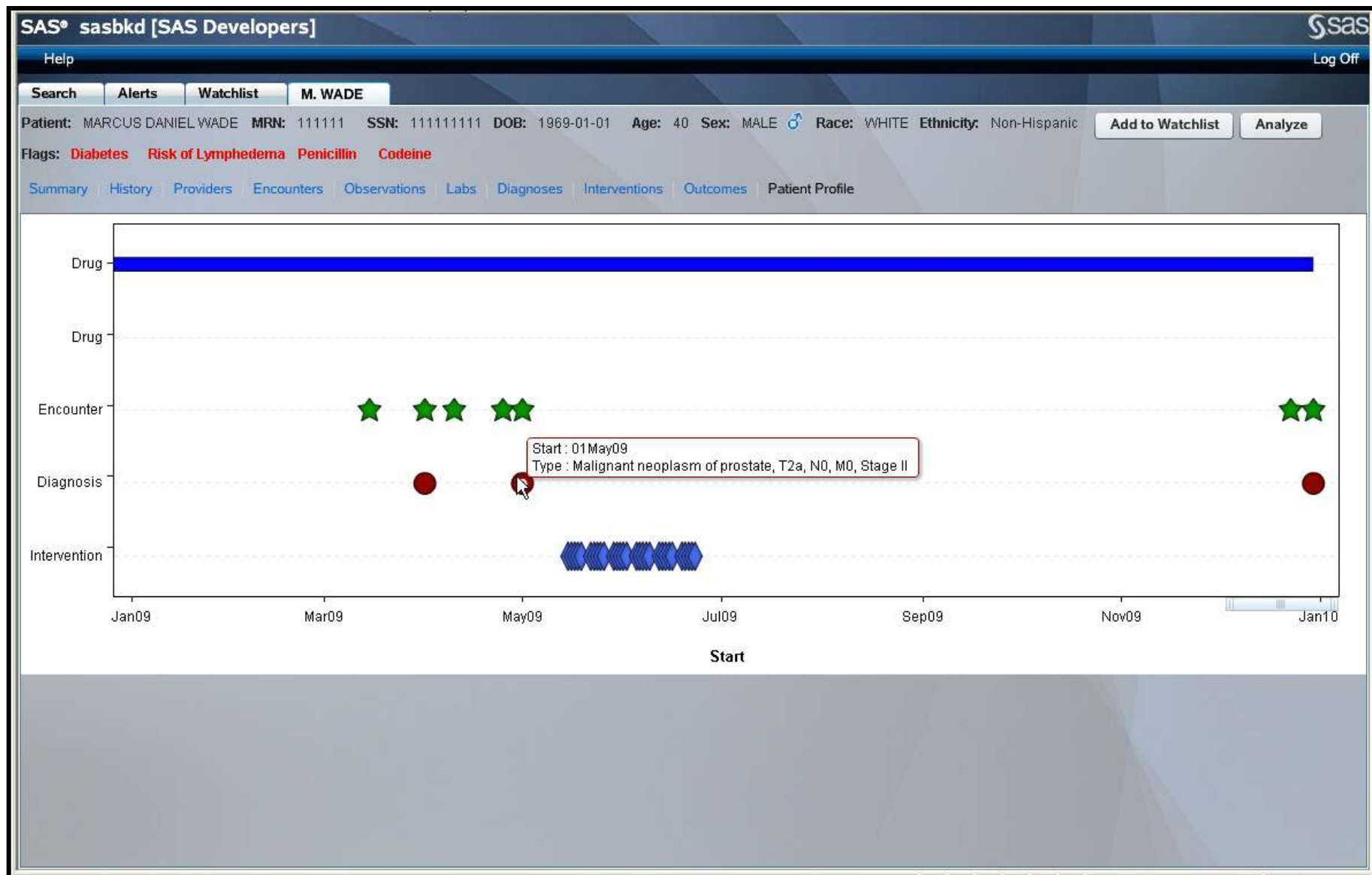
SummaryHistoryProvidersEncountersObservationsLabsDiagnosesInterventionsOutcomesPatient Profile

Date	Code	Description
Jun 5, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
Jun 5, 2009	CPT 51702	Insertion of a temporary indwelling bladder catheter, simple (Foley).
Jun 2, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
Jun 1, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 31, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 30, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 29, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 26, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 25, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 24, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 23, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 22, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 19, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 18, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 17, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 16, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
May 15, 2009	CPT 4200F	External Beam Radiotherapy To Prostate Only (Prca)1
Apr 25, 2009	CPT 55700	Biopsy of prostate
Nov 29, 2006	WHO 5640	Ibuprofen per label until pain subsides (approx 1 week)
Nov 27, 2006	CPT 29888	Repair torn ACL
Jun 2, 2000	WHO 72210	Accupril (quinapril hydrochloride) - 1 capsule daily

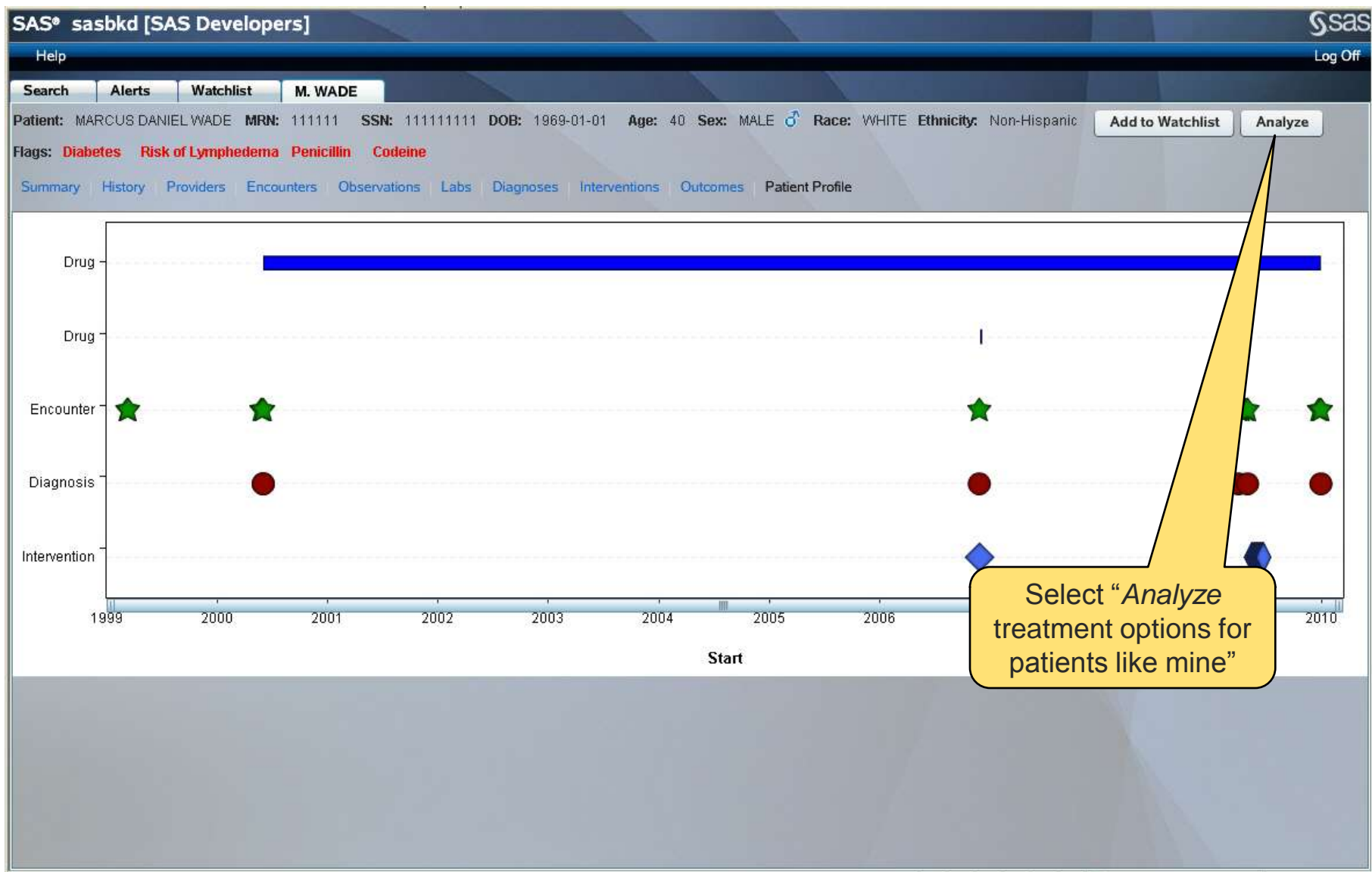
# Patient Outcomes

SAS® sasbkd [SAS Developers]				sas	
Help				Log Off	
Search	Alerts	Watchlist	M. WADE		
Patient: MARCUS DANIEL WADE MRN: 111111 SSN: 111111111 DOB: 1969-01-01 Age: 40 Sex: MALE ♂ Race: WHITE Ethnicity: Non-Hispanic				Add to Watchlist	Analyze
Flags: Diabetes Risk of Lymphedema Penicillin Codeine					
Summary	History	Providers	Encounters	Observations	Labs
Diagnoses	Interventions	Outcomes	Patient Profile		
Date	Code	Value	Description		
12/30/2009	PSA	20	19.8 Change from baseline		
12/30/2009	ECOG Performance Status	2	Ambulatory and capable of all self-care but unable to carry out any work activities. Up and about more than 50% of waking hours.		
06/19/2009	ICD-9	607.84	Erectile Dysfunction		
06/19/2009	ICD-9	599.69	Urinary obstruction		
06/19/2009	ICD-9	788.65	Straining on Urination		
06/19/2009	ECOG Performance Status	1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work.		
06/12/2009	ECOG Performance Status	1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work.		
06/5/2009	ICD-9	599.69	Urinary obstruction		
06/5/2009	ICD-9	788.65	Straining on Urination		
06/5/2009	ECOG Performance Status	1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work.		
05/29/2009	ECOG Performance Status	1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work.		
05/22/2009	ECOG Performance Status	1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work.		
05/15/2009	ECOG Performance Status	1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work.		
05/1/2009	ECOG Performance Status	0	Fully active, able to carry on all pre-disease performance without restriction.		
04/1/2009	ICD-9	599.69	Urinary obstruction		

# Patient Profile Timeline (1 year view)



# Patient Profile Timeline (Multi-year view)



# Example Summary Analysis:

## *Subset Data and Analyze Treatments*

- Automatically find cohort of patient that is similar to selected patient based on prognostic factors
  - Example: Prostate cancer  
Age group, sex, race, ethnicity, family history, personal history, PSA, prostate hypertrophy, urinary or rectal incontinence, Gleason score, TNM, and stage
- Obtain values from selected patients and find cohort with the same values
- Look for all treatment combinations found in this subset of data
- Analyze outcomes per treatment combination



# Compare Outcome Distributions

## Per Treatment Sequence

Analyze

Chart Report Patient Detail

Select an Outcome for comparison: Mean Change ECOG Score

### Patient Info

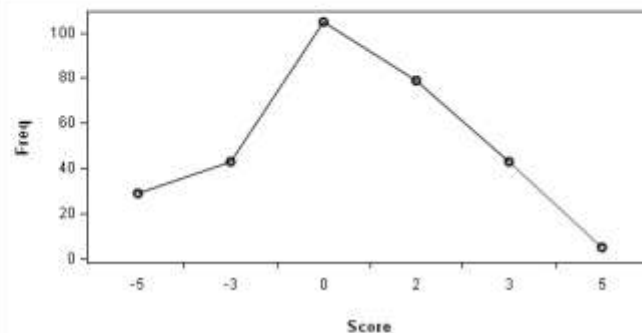
#### Data Subset

Attribute	Value
<input checked="" type="checkbox"/> Gender	Male
<input checked="" type="checkbox"/> Age Group	65-69
<input checked="" type="checkbox"/> Race/Ethnic Group	Black
<input checked="" type="checkbox"/> Family History #1	Y
<input checked="" type="checkbox"/> Prostate Size Fla	Y
<input checked="" type="checkbox"/> PSA Flag	Y
<input checked="" type="checkbox"/> PSA Change Flag	Y
<input checked="" type="checkbox"/> Alcohol	Moderate
<input checked="" type="checkbox"/> Smoker	No
<input checked="" type="checkbox"/> Clinical Stage	2
<input checked="" type="checkbox"/> Biopsy Stage	HA
<input checked="" type="checkbox"/> Incontinent	N

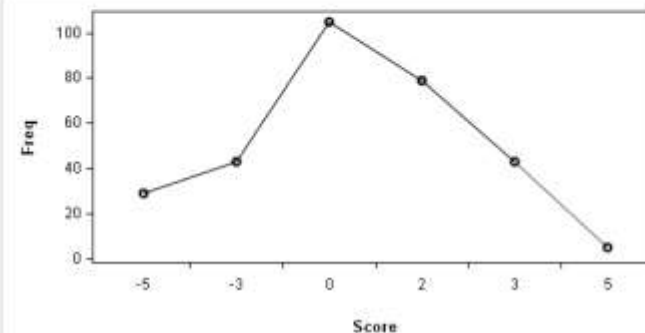
Analyze

Reset me

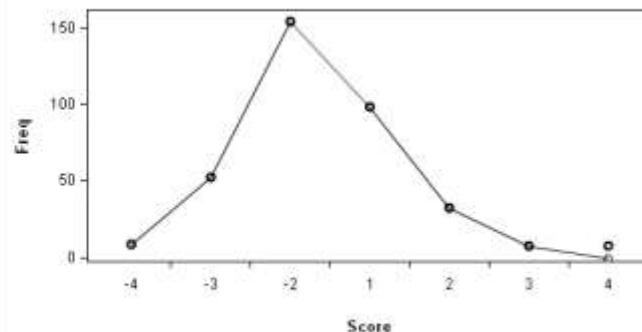
RPS Only



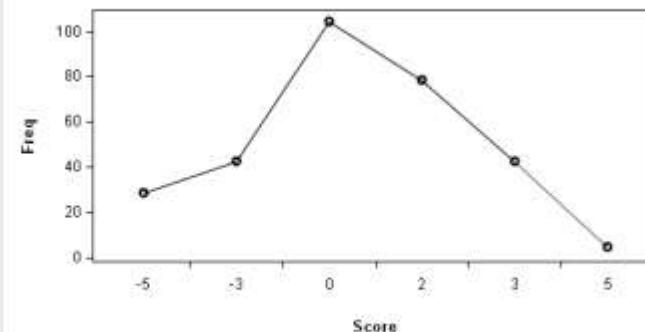
IMRT



RPS/LHRH Antagonist

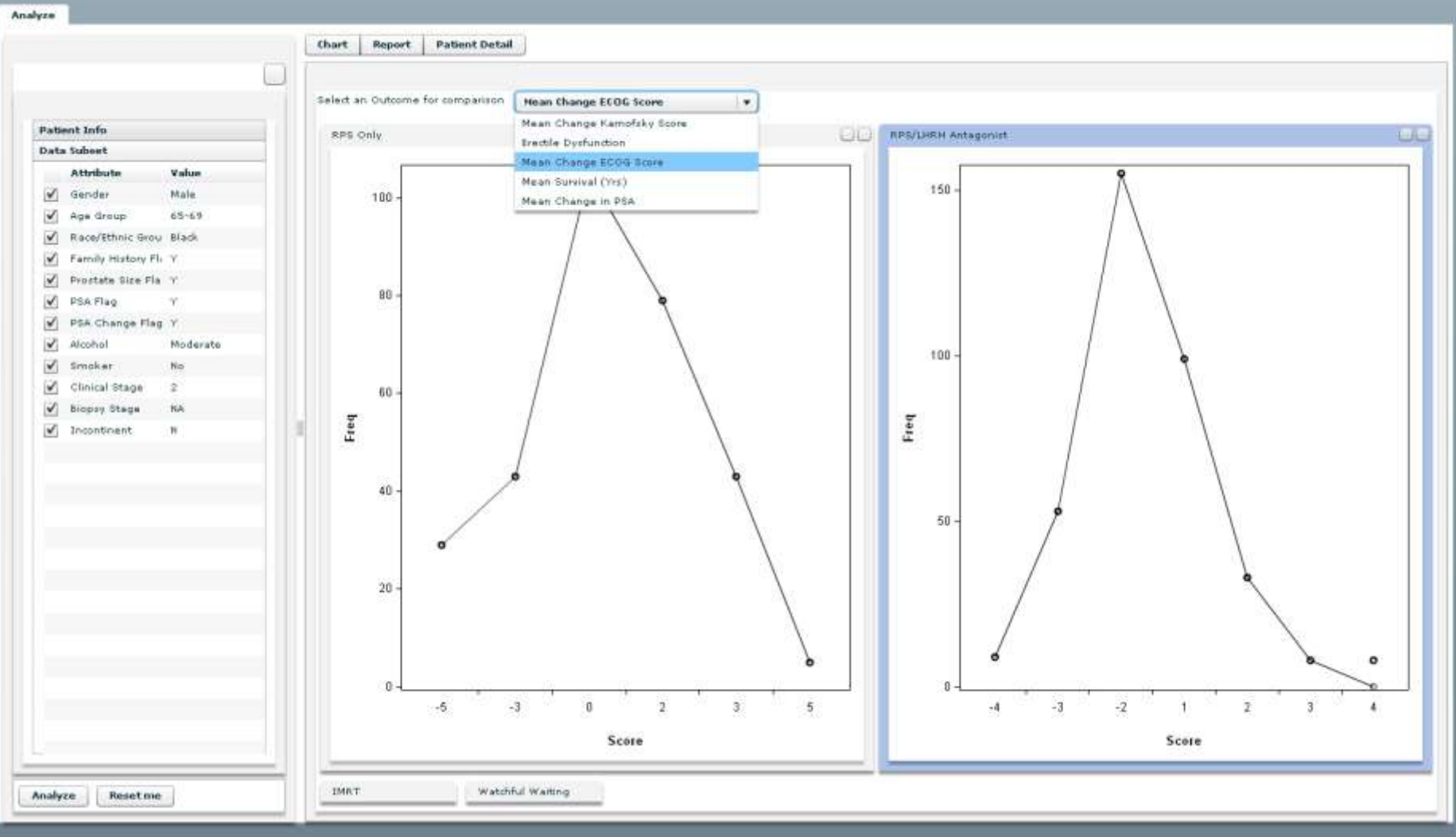


Watchful Waiting



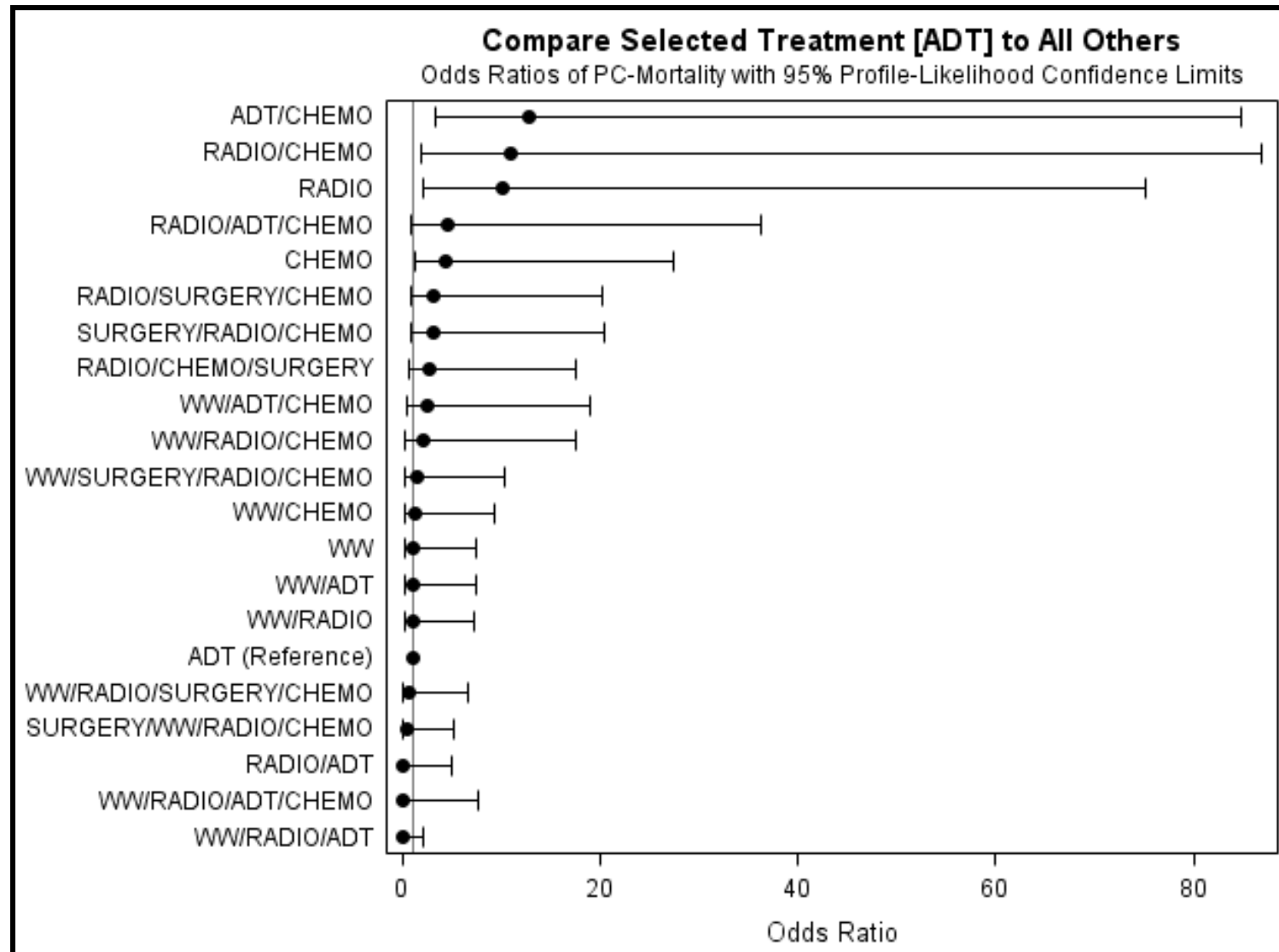
# Rearrange Graphs

## Or Select Different Outcome Measure



# Comparing Mortality Due to Prostate Cancer

## For Androgen Deprivation Therapy Compared to All Other Treatments

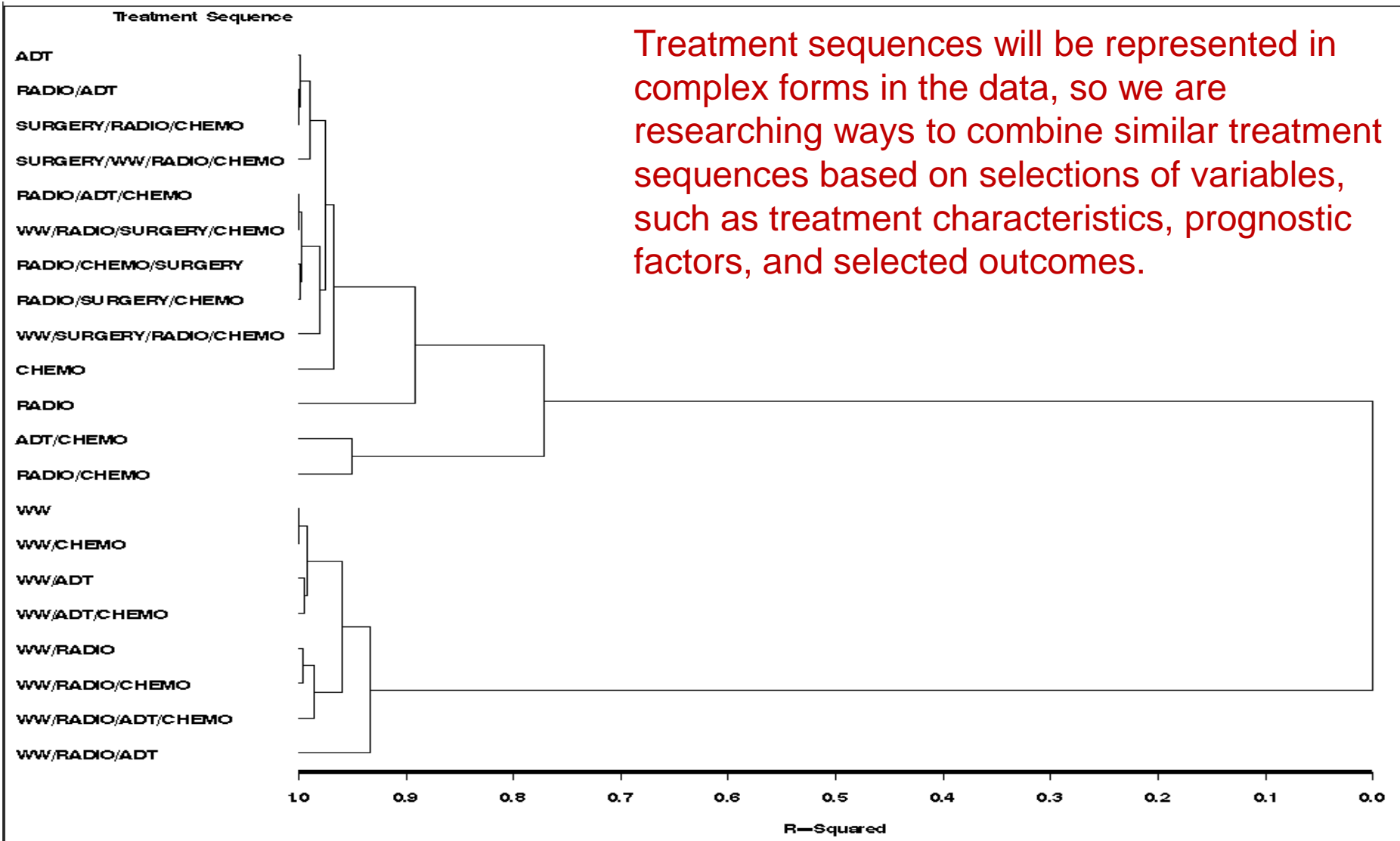


# Advanced Analytics

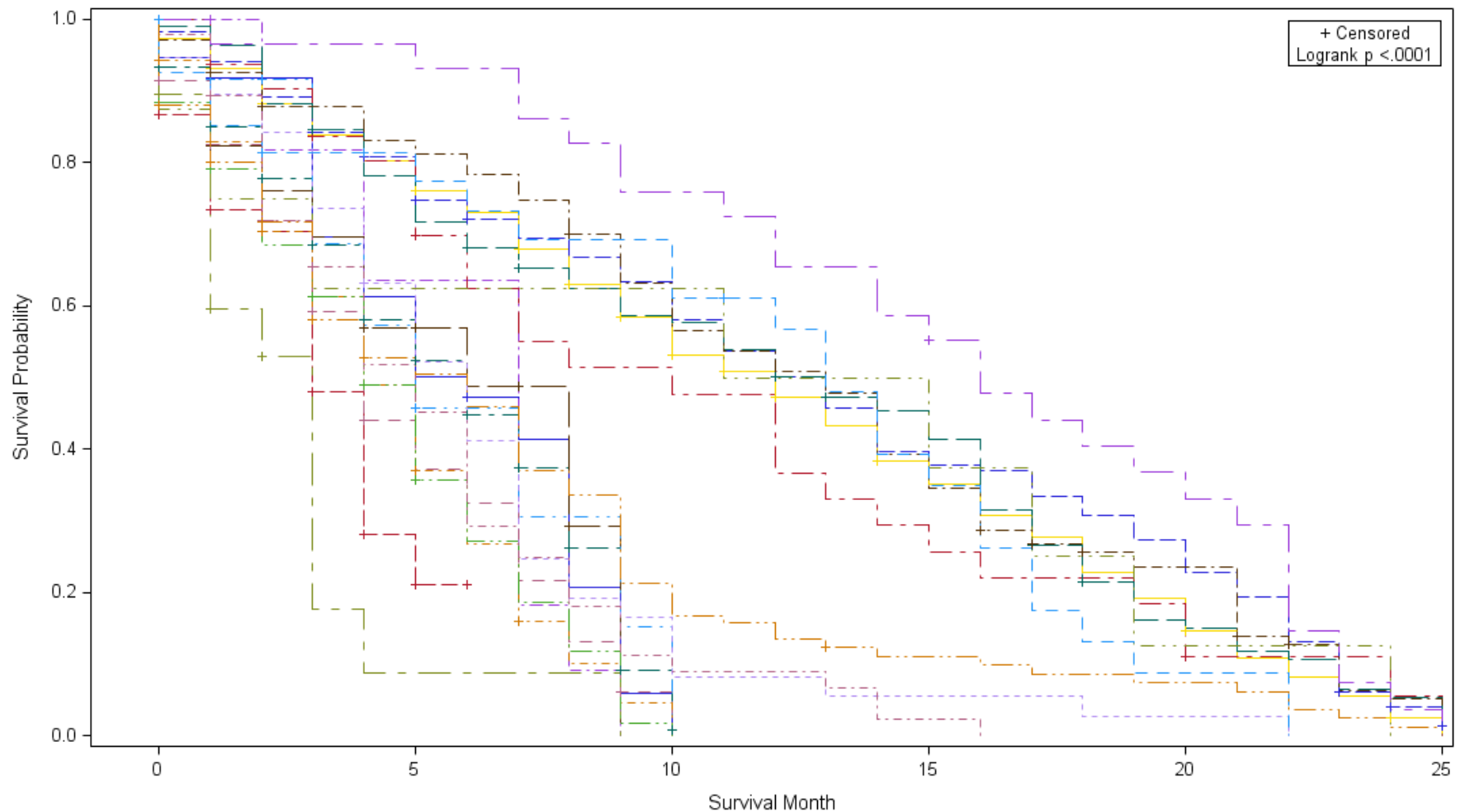
- The examples shown represent basic summarization for routine assessment of past outcomes
- Currently exploring advanced methods of analysis such as:
  - Attribute profiling and clustering
  - Treatment profiling and clustering
  - Association analysis for risk and prognostic factors and outcomes likelihood and probability
  - Simulation
  - Risk and prognostic prediction models per HOI
- Analysis is dependent on receiving patient data from NCCCPs.

# Experimental Clustering of Treatments

Treatment sequences will be represented in complex forms in the data, so we are researching ways to combine similar treatment sequences based on selections of variables, such as treatment characteristics, prognostic factors, and selected outcomes.

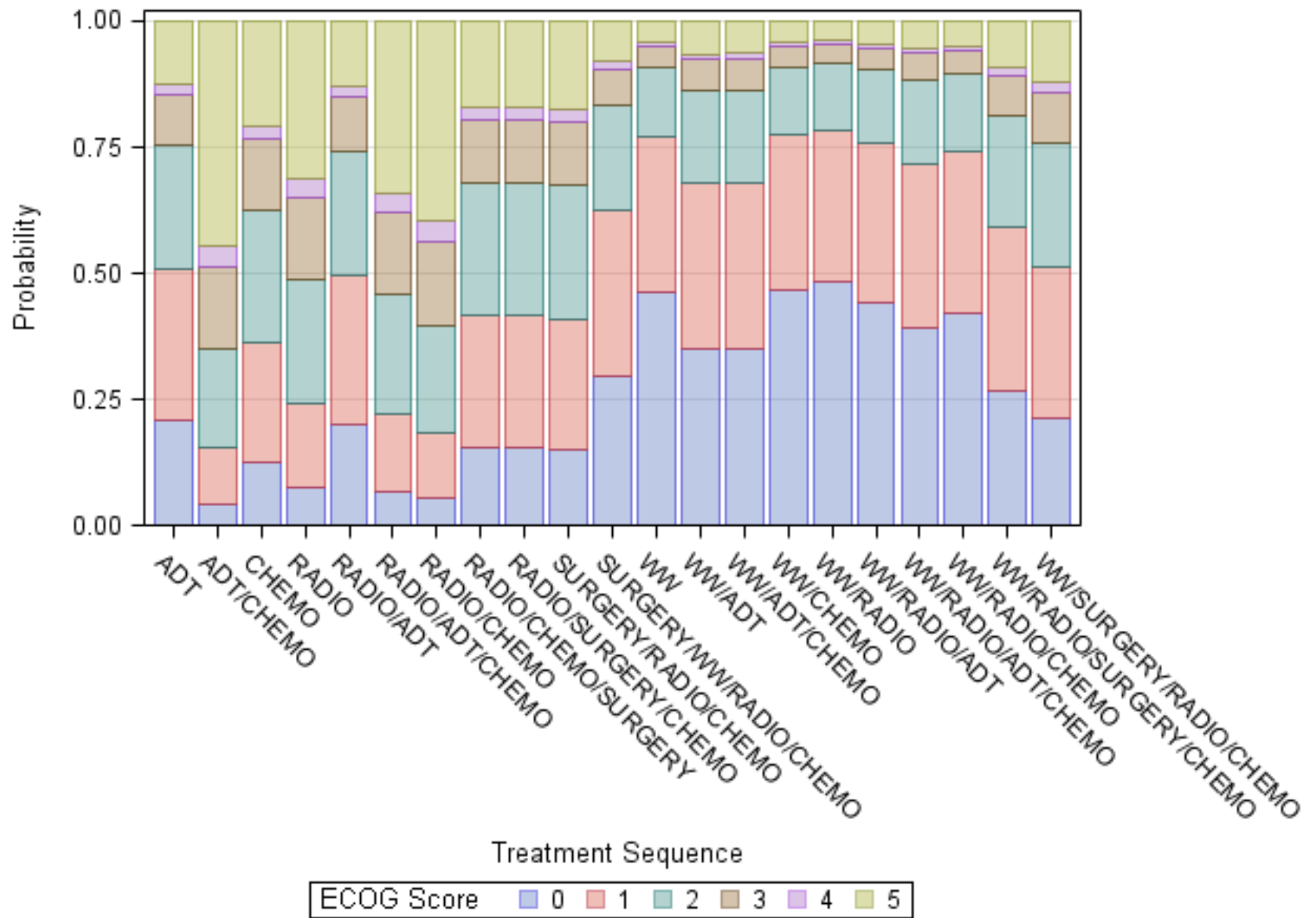


# Product-Limit Survival Estimates

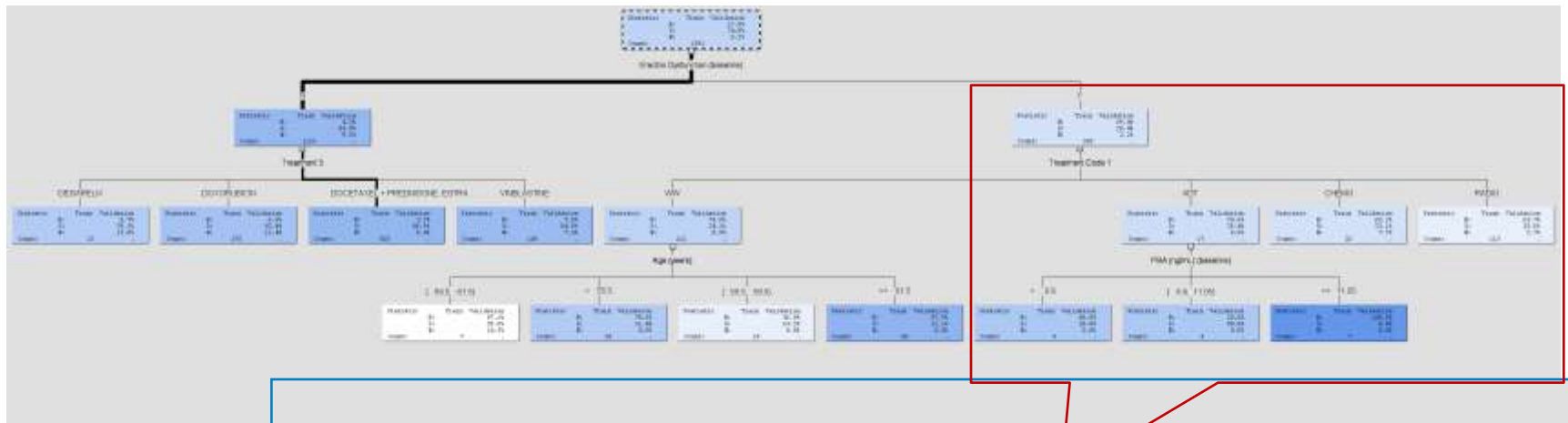


TreatmentSequence		
ADT	ADT/CHEMO	CHEMO
RADIO	RADIO/ADT	RADIO/ADT/CHEMO
RADIO/CHEMO	RADIO/CHEMO/SURGERY	RADIO/SURGERY/CHEMO
SURGERY/RADIO/CHEMO	SURGERY/WW/RADIO/CHEMO	WW
WW/ADT	WW/ADT/CHEMO	WW/CHEMO
WW/RADIO	WW/RADIO/ADT	WW/RADIO/ADT/CHEMO
WW/RADIO/CHEMO	WW/RADIO/SURGERY/CHEMO	WW/SURGERY/RADIO/CHEMO

### Predicted Cumulative Probabilities for ECOG

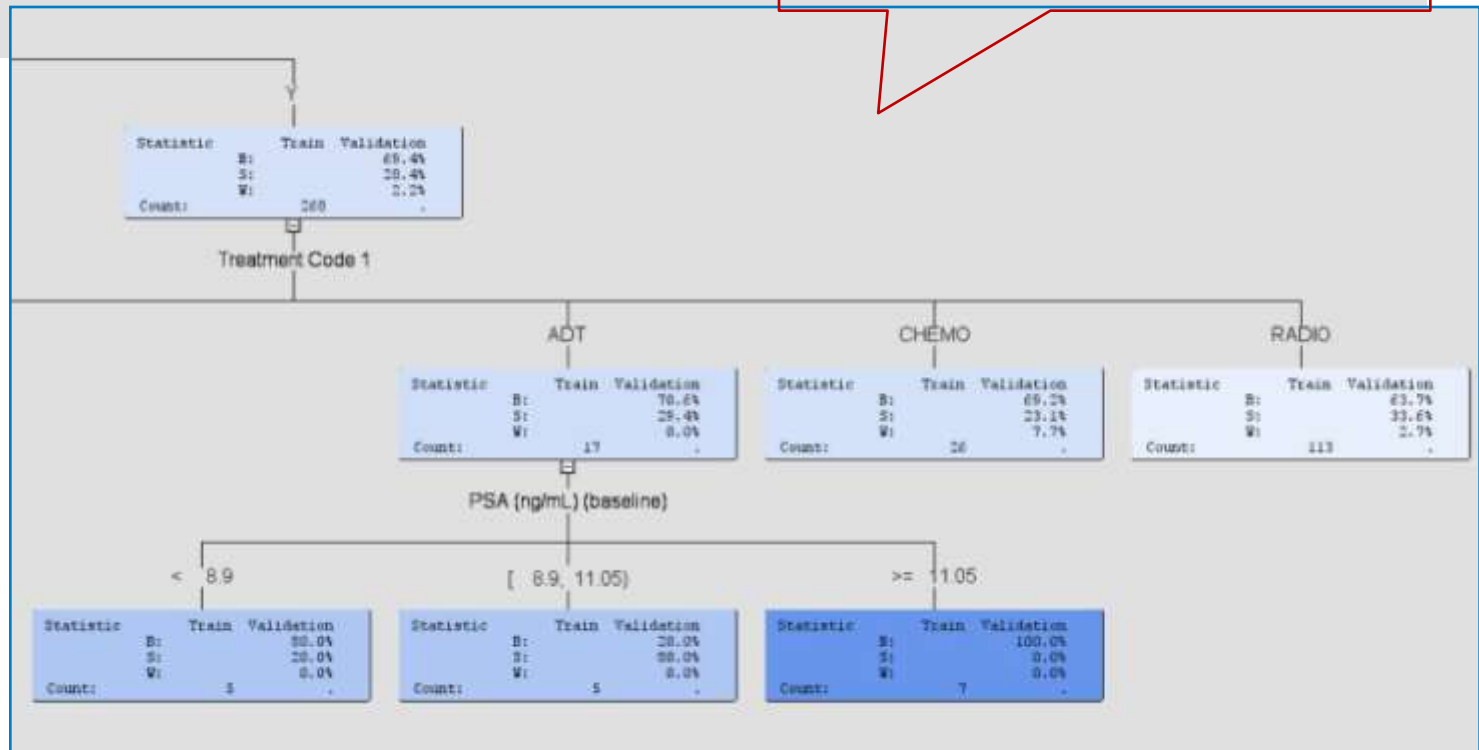


# Decision Tree Analysis

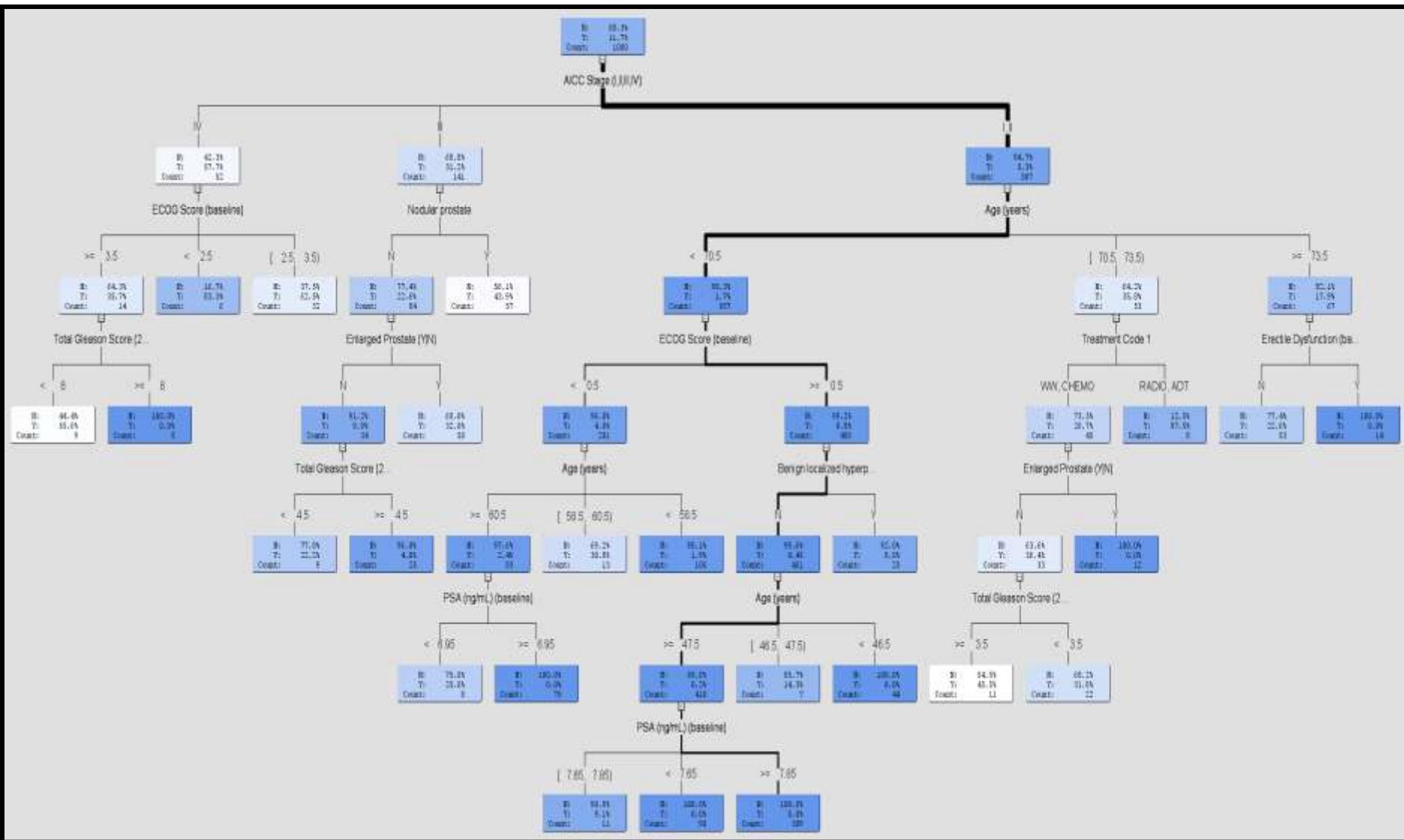


Which treatment sequence and patient attributes are associated with an outcome?

E.D.  
Better,  
Same, or  
Worse

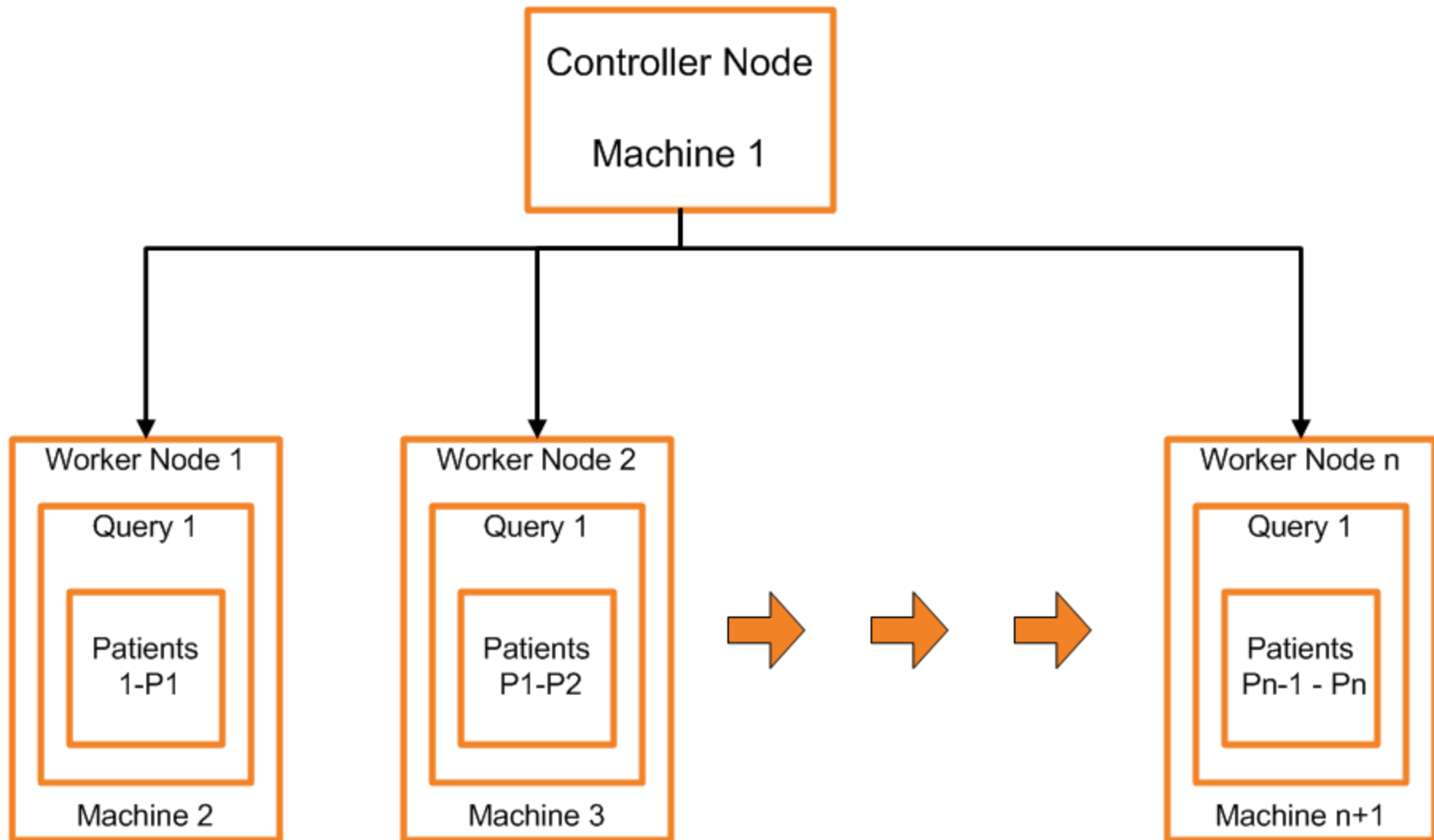


## Decision Tree: Predicted Change in Mortality



# High Performance Analytic Computing

*Massively Parallel Process Database*



32

# High Performance Analytic Computing

## *In-Database Processing*

- Statistical methods executed within the database
  - Thereby reducing data transfer
- SAS Data Step processing also supported
- Combination of in-database and parallel processing yields big performance boost

# Summary

The Combination of:

- Collaboration
- Community
- Medical knowledge and experience
- Technology
- Statistics
- Optimization
- SaaS and Cloud Computing

Leading to better patient outcomes

